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ABSTRACT

This study contrasted the science-related cognitive skill attainment of children experiencing high and low individualized science programs. Teachers involved in the study were classified as high-individualized or low-individualized according to the degree of individualized instruction they practiced as measured by the Instructional Practices Questionnaire. A total of 903 fifth-grade pupils from seven schools were given five subtests of the Bristol Study Skills Test: properties, structures, processes, explanations, and interpretations. Statistical analysis of test scores showed that students from high individualized classrooms scored significantly higher on the first four of the five Bristol subtests. (SB)

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CONTRASTING CHILDREN'S SCIENCE-RELATED COGNITIVE SKILLS IN HIGH AND LOW INDIVIDUALIZED CLASSROOMS*

by

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The movement in education to individualize instruction for students grew largely out of the sixties. Programs such as Individually Prescribed Instruction (IPI) and Program of Learning in Accordance with Needs (PLAN) gave impetus to the movement (see Flanagan, 1967; and Bolvin and Lindvall, 1965).

Efforts to individualize instruction in science continue on into the seventies. Along with other subject areas, PLAN* is being marketed by Westinghouse Learning Corporation (Patterson, 1970), and IPI is being distributed by Research for Better Schools in Philadelphia. Individualized minicourses for high school science are currently being developed at Florida State University and marketed by Ginn and Company (Burkman, 1974).

Although some studies have been completed that report the cognitive results of such programs, little is known about the relationship between the degree of individualization and student achievement. Frequently programs are labeled as "individualized" with no attempt to quantify the degree to which the program approaches an ideal defined by specific criteria. This oversight todescribe the independent variable adequately creates problems in attributing cognitive or affective differences to treatment conditions.

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The major efforts of this study were to develop an instrument that would quantify the degree of individualization and then contrast the cognitive skill attainment of children from high and low individualized settings.

Problem and Definitions

The specific question explored in the current study was: when classrooms are classified as high or low individualized, are there major differences in the science-related cognitive skills of children?

For purposes of this study the following definitions will apply:

Individualized instruction. A student centered approach to learning wherein individual student differences are taken into account when designing each student's program of study. The ideal approach to individualized instruction provides alternatives to students in these five areas: 1) the variety of content available; 2) the amount of content required; 3) the rates of learning expected; 4) the sequence of the content provided; and 5) the variety of methods or activities used.

Science-related cognitive skills. Includes those science-related intellectual abilities that help the child understand and inquire into his physical environment. Examples of these skills include the following: 1) the ability to make inferences about the physical properties of objects, their structure and interactions in different situations; 2) the ability of children to produce explanations about their experiences with materials in classificatory or conservatory situations; and 3) the ability to make interpretations of graphic and pictorial materials.

The Sample

Three samples are of concern in the present study. The first is a

sample of teachers employed by the Broward County, Florida, Public Schools. This sample was utilized to field test the Instructional Practices Questionnaire, a self-reporting instrument to measure the degree of individualized instruction being practiced. The second sample consisted of seventeen fifth grade teachers of science from the Broward County Schools. This sample together with the students they were teaching constituted the target groups for exploring the research question in this study. The students taught by the seventeen teachers were given a science cognitive instrument and a brief questionnaire described below.

The Instruments

1. Instructional Practice Questionnaire (IPQ) - measures the degree of individualized instruction taking place in a classroom. The instrument was developed by the investigator and the Broward County Research Department (see Appendix A for an example).
2. Bristol Study Skills (The Bristol) - An abbreviated version of the commercial version of this test was utilized in this study. Buros' Seventh Mental Measurements Yearbook (1972) suggest the test measures cultural and scientific knowledge of the environment. The following subtest scores are included in the scoring: Properties: emphasis here is on inferences about materials and situations; Structures: emphasis is on Piaget's conservation of substance, weight, etc.; Processes: emphasis is on interpolating mechanical situations; Explanations: emphasis is on Piagetian conservation, classification and scientific reasoning; and Interpretations: emphasis is on knowledge of graphic and pictorial symbols. The estimate of reliability for the entire test was .90 as derived from the publisher's reliability coefficient.

3. Student Questionnaire (SQ) - this questionnaire is an instrument designed to validate teacher responses on the IPQ. Questions explore student perceptions as to the general mode of instruction in science. (See Appendix B for an example.)
4. Parents' Educational Level (PEL) - describes the highest grade level completed by either parent. The information was acquired from school registration forms. A coding scheme was developed to code the grade levels reported. (See Appendix C for an example.)

Procedures:

The research plan consisted of the following steps:

1. develop the IPQ;
2. field test the IPQ on a large population of teachers;
3. administer the Bristol and Student Questionnaire to their students;
4. analyze the data.

Development of the IPQ focused upon developing questionnaire items that would differentiate teachers according to the kinds of individualized instruction practices they were applying in their classrooms. Items were purposefully written in such a manner as to adequately cover the five dimensions of individualized instruction previously stated in this paper. Content validity was established by using the reviews of a variety of curriculum supervisors in the county. Data were later used to establish more objective validation of the instrument; this result is reported later in this paper.

Not all of the items on the IPQ relate directly to individualizing instruction. Rather, some items measure procedures that might facilitate

individualization. For instance, items 1 and 22 relate to grouping techniques. Therefore, from the original questionnaire eleven items were keyed directly to individualized instruction, i.e., items 2, 5, 7, 8, 12, 14, 17, 18, 19, 21, and 23. The remaining items were used in other county research.

The field test of the IPQ was completed using 298 reading teachers and 270 math teachers. The estimate of reliability for the eleven items based on the responses of the reading teachers was .74 while the reliability for the math teachers was .79. A principal components analysis of the eleven items resulted in every item loading on one common factor in the case of mathematics teachers and all but one loading in the case of reading teachers.

Before teachers were chosen to complete the science IPQ, certain strategies had to be planned. Not all teachers who had completed the other IPQ's would also be teachers of science. Only teachers of science were needed in the current study. It was decided that most likely science would be individualized in those schools that had other individualized subjects operating. Similarly, schools with other low individualized subjects would most likely yield a low individualized science program... at least it seemed more likely than if teachers were chosen completely at random.

In order to maximize the probability of getting differences on the criterion variable between high and low individualized settings, schools had to be selected according to carefully considered criteria. It was highly desirable to select schools, first of all, that could be clearly classified as high or low individualized. This was accomplished by dividing the schools' IPQ mean scores into quartiles, the upper quartile

containing high individualized schools, the lower quartile the low individualized schools. Secondly, it was important that teachers within the school have low variability in their IPQ scores. Thus, the IPQ standard deviations of the teachers within the schools became important statistics in this selection process. The mean scores and standard deviations for the seven schools eventually chosen are shown in Table 1.

Table 1.

Means and Standard Deviations of Seven Schools

Selected for the Study Based on Key IPQ Items

	School	Number of Teachers	Reading IPQ Mean	Reading IPQ SD	Mathematics IPQ Mean	Mathematics IPQ SD	Total IPQ Mean Scores
High Individualized	40	1	44.3	2.08	43.0	0.0	87.3
	50	5	44.2	5.85	37.6	4.9	81.8
	60	1	42.8	4.57	50.0	0.0	92.8
	70	4	42.8	4.32	38.7	10.7	81.5
Low Individualized	10	1	29.8	7.82	31.9	7.7	61.7
	20	3	30.7	1.16	35.7	2.3	66.2
	30	2	25.5	5.34	26.6	3.7	52.1

The sever schools chosen were requested to have their fifth grade teachers of science complete the IPQ and give their students the Bristol and Student Questionnaire.

Data Analysis

Since data from the five subtests of the Bristol were analyzed,

multivariate analysis of covariance (MANCOVA)[1] served as the method of analysis. The five subtests of the Bristol served as the dependent variables, while parents' highest educational level (PEL) was the covariate.

To determine the effect of the degree of individualized instruction on student performance on the dependent variables, teachers were classified into groups based on their science IPQ scores. The top one-third teachers were classified as high individualized, the middle third as medium individualized and the bottom one-third as low individualized.

In order to answer the research question, the effect of each teacher was treated as a nuisance factor in the study. It was assumed that all children in a particular class had to conform equally to the degree of individualization reported by the teacher via the IPQ. The statistical analysis applied was hierarchical in design with the effect of teachers nested within the high-low individualized groups. The advantage of the nested design is that it isolates a source of variation that affects scores (Kirk, 1968, p. 229). The source of variation in the present study came from differences between teachers within the high and low individualized groups of teachers.

Using the nested design, a comparison between two groups was executed, i.e. a comparison of Bristol subtest means was made between classrooms classified as high individualized or low individualized.

Findings

Scores on the science Instructional Practices Questionnaire (IPQ) for the seventeen teachers ranged from 21 - 48 with a mean of 36 and a standard

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[1]See Cooley and Lohnes (1971) for a description of this analysis.

deviation of 6.98. The correlation between the SQ classroom mean scores and teachers' IPQ scores was +.47, a moderate relationship pursuant to validating teachers' self-reports of instructional practice.

In all, 903 fifth grade students completed the Bristol Test. The total scores ranged from 1-45 with a mean of 25.7 and a standard deviation of 9.3. The standard error of the estimate was 0.31. Table 2 summarizes the data associated with seven high individualized teachers and six low individualized teachers.

Table 2.

Student/Teacher Data in High and Low Individualized Classrooms

	Teacher	IPQ Score	PEL	SQ	Bristol Mean	SD
High Individualized	71	48	6.6	14.3	30.0	6.8
	72	47	6.6	13.8	30.4	6.6
	73	44	6.6	13.6	32.2	7.4
	61	41	6.2	11.2	28.1	7.8
	54	41	5.1	9.5	22.4	10.7
	74	39	6.6	14.3	31.2	7.6
	41	39	5.2	11.4	22.9	9.9
Low Individualized	22	32	6.2	10.8	27.0	8.7
	31	31	4.7	11.1	23.7	9.2
	23	30	6.2	11.1	29.1	9.0
	53	29	5.1	11.8	18.7	9.1
	11	28	4.5	11.1	24.2	8.6
	32	21	4.7	11.9	20.4	9.8

The Bristol subtest means and standard deviations for students coming from high individualized classrooms and low individualized classrooms are provided in Table 3. As indicated in the table, high individualized students attained higher mean scores on every part of the Bristol test. To assess whether these scores were actually significantly different between the groups, a multivariate analysis of covariance (MANCOVA) was performed with parents' educational level (PEL) as a covariate.

Table 3.

Bristol Means and Standard Deviations for Students From Classrooms Differing in the Degree of Individualized Instruction

Bristol Subtest		High Individualized (N=321)	Low Individualized (N=380)*
I. Properties	M	7.9	6.7
	SD	2.5	2.7
II. Structures	M	6.6	5.9
	SD	2.9	3.0
III. Processes	M	4.3	3.8
	SD	1.7	1.8
IV. Explanations	M	3.7	3.2
	SD	1.7	1.6
V. Interpretations	M	5.2	4.7
	SD	2.2	2.2
Total Bristol	M	27.7	24.3
	SD	8.8	9.2

To assess usefulness of this variable as a covariate, a test of within cells regression was included in the MANCOVA output. An F-ratio of 6.3 (df = 5, 683) was significant beyond the .001 level. This indicated that PEL was significantly related to the criterion variables, i.e., the five subtests of the Bristol. Hence, PEL was regarded as a useful covariate in the analysis of this research question.

Included in the multivariate analysis of covariance output for this first question was a test for significant differences in the unique variance associated with each teacher within the high and low individualized groups. The overall results produced an F-ratio = 2.3, $p < .001$. The univariate tests resulted in significant differences between teachers ($p < .01$) in all five instances. These significant differences that existed between classrooms on the Bristol subtests suggested that unique effects between teachers or classrooms were operating in the present situation. The nested design chosen for the analysis of this research question subsequently partitioned this variance from the error variance, the results of which are reported below.

The multivariate test of overall Bristol differences between high and low individualized classrooms was significant (F-ratio = 5.3, df = 5, 683) beyond the .001 level. The result, favoring high individualized classrooms, controlled for parents' educational level and unique teacher effects. The univariate tests indicated that students from high individualized classrooms scored significantly higher on the first four of the five Bristol subtests. The F-ratios and p values for each of the Bristol parts are provided in Table 4.

Table 4.

Multivariate and Univariate Tests of Significance

Contrasting High vs. Low Individualized Groups

Bristol	Univariate F-ratios (1, 687 df)	P Less Than
Properties	21.5	.001
Structures	8.2	.004
Processes	7.7	.006
Explanations	14.0	.001
Interpretations	2.7	.099

MANCOVA F-ratio = 5.3, df = 5, 683

Discussion and Conclusions

Students experiencing high individualized classrooms had total Bristol mean scores of 27.7 while low individualized students scored 24.3 on the Bristol. These raw score mean values, favoring the high individualized classrooms, were significantly different ($p < .001$) even when parents' educational level and unique teacher differences were controlled in the analysis. Assuming similar cognitive levels at the start of the study, the results seem to support the contention that higher levels of science-related cognitive skills are associated with a higher degree of individualized instruction situation.

Taken at face value, Parts I, II, and III theoretically should be able to detect differences in the benefits of the manipulative experiences of children. This study seems to bear out this contention since students performed best on these tests when they came from high individualized

science situations -- situations in which they had been able to conduct their own experiments. Students experiencing more passive, teacher-directed programs did less well when asked to reason through natural interactions and processes presented in these parts of the Bristol.

The other Bristol subtest that had major differences between high and low individualized classrooms was Part IV, Explanations. This part of the Bristol is concerned with Piagetian conservation, classification and scientific reasoning. The Bristol Interpretive Manual (Brimer, 1969) suggests that the main theme of Part IV is "ways of accounting for experience". As with the other subtests, this subtest's results favor high individualized classrooms. Perhaps with youngsters in high individualized classrooms conducting their own science activities, greater practice and experience is gained in dealing with concrete problems. As pupils work with materials, plan and perform experiments, much reasoning is required to synthesize their experiences in meaningful ways. It appears that pupils who do have more frequent experiences in working on and thinking through their own problems in science are more likely to perform well on Part IV, Explanations.

Part V of the Bristol, Interpretations, produced the only non-significant F-ratio between high and low individualized classrooms. This subtest of the Bristol is regarded by the test makers to be the most difficult. It deals chiefly with abilities to make inferences from diagrams or symbolically presented data. As it turned out both groups achieved the highest proportion of correct responses on this part of the Bristol. A major skill utilized in Interpretations is one that is frequently included and reinforced by mathematics and social studies instruction, thus both groups should have performed well on this subtest in contrast to the other parts.

Furthermore, since interpretations do not necessarily depend on numerous manipulative activities, the experiential advantage held by the high individualized group seems to be less important to performance on this subtest.

Implications of the Study

In school systems where many teachers claim to be individualizing, better psychometric techniques need to be developed to classify teachers on an individualized instruction continuum. When the conditions are ill-defined, it is impossible to make inferences about relationships between these conditions and performance differences. One approach suggested by the present study is to utilize a teacher self-reporting measure, the Instructional Practices Questionnaire. Using such a questionnaire, system-wide assessments describing instructional practices would be feasible. Such an inventory effort would greatly help school systems describe what their schools are actually doing to individualize instruction.

That students who experience high individualized science program develop higher levels of science cognitive attainment, supports the beliefs of many science educators. For years science educators have claimed that student-centered, inquiry-oriented classrooms are more desirable than teacher-centered, reading-oriented science classes. Fewer educators have been willing to commit themselves to individualized modes of instruction, even though many will support it in theory. This study lends support to those who believe that students need to be active participants in the exploration of scientific problems. The processes of science seem to be best understood when students practice them in high

individualized classrooms.

If science-related cognitive skills are to be included as goals of schools, then appropriate modes of instruction that foster such skills need to be included in the schools' programs. The results of this study suggest that higher levels of cognitive growth seem to be related to the degree of individualized classroom structure and the opportunities for students to perform *their own* investigations.

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APPENDIX A

INSTRUCTIONAL PRACTICES QUESTIONNAIRE

_____ _____

Teacher Name School

I. General description of teaching situation:

1. In which type of setting do you teach science?

Standard classroom (four solid walls)_____

Portable classroom _____

Pod or suite (two or more rooms with sliding walls between) _____

Flexible or open space (two or more rooms with no walls between, solid or sliding) _____

Other(Specify_____)

2. How many university courses have you taken in the teaching of science? Specify the number of courses (not credit hours) here: _____

3. How many years of science teaching experience do you have?

0 - 2 years _____

3 - 6 years _____

7 or more _____

4. How many years have you taught at your present school?

0 - 2 years _____

3 - 6 years _____

7 or more _____

II Instructional methods used in your formal science program:

Please answer each of the following items according to the frequency a stated activity occurs in your teaching situation. If you do not teach formal (directed) science do not complete this section.

For each item, please circle the number next to the statement that best describes your situation. Use the following scale:

5 - Very frequently occurs
4 - Often occurs
3 - Sometimes occurs
2 - Rarely occurs
1 - Never occurs

1.	Pupils within a class are grouped homogeneously on achievement or performance in this subject.	1 2 3 4 5
2.	Teaching is directed to an entire class in this subject.	1 2 3 4 5
3.	Instruction is directed to temporarily formed skills groups in this subject.	1 2 3 4 5
4.	Students receive skills instruction through individual pupil-teacher conferences.	1 2 3 4 5
5.	Pupil's progress proceeds at the pace of the group to which he is assigned.	1 2 3 4 5
6.	Pupils are given individualized assignments only after they have completed the required group assignments.	1 2 3 4 5
7.	Pupil's progress is paced by individually prepared prescriptions or contracts.	1 2 3 4 5
8.	Pupils help plan assignments with teachers on a one-to-one basis.	1 2 3 4 5
9.	Pupils maintain a record of their own progress.	1 2 3 4 5
10.	Instruction is sequenced in this subject primarily on teacher judgment.	1 2 3 4 5
11.	Instruction is sequenced in this subject according to a teachers' manual.	1 2 3 4 5
12.	A variety of learning activities occur at the same time in this subject.	1 2 3 4 5
13.	Pupils change skill groups as their performance changes.	1 2 3 4 5
14.	Pupils are allowed to initiate studies in curriculum topics from a higher grade level whenever they are ready.	1 2 3 4 5
15.	I plan my students' instruction with other teachers.	1 2 3 4 5

5 - Very frequently occurs
4 - Often occurs
3 - Sometimes occurs
2 - Rarely occurs
1 - Never occurs

16. My students have individual conferences with me at least onee a week.	1	2	3	4	5
17. The same tests and other forms of evaluation are given to an entire class of pupils at the same time.	1	2	3	4	5
18. Pupils initiate changes in topics of study in this subject.	1	2	3	4	5
19. Diagnostic tests are given to pupils on an individual basis when pupils are ready to make changes in their programs of study.	1	2	3	4	5
20. Instructional groups in this subject are cross-graded (i.e., pupils from two or more grades are in the same group).	1	2	3	4	5
21. All students are expected to learn the same amount of material or the same number of skills.	1	2	3	4	5
22. Pupils are grouped according to their interests in this subject.	1	2	3	4	5
23. Instruction is uniquely sequenced for each student in this subject area.	1	2	3	4	5
24. For instruction in this subject groups are heterogeneous.	1	2	3	4	5
25. Students use a variety of books in their science instruction.	1	2	3	4	5
26. Reading and writing about different science topics is the chief mode of instruction.	1	2	3	4	5
27. Pupils record observations and data from <u>their own</u> experiences.	1	2	3	4	5
28. Commercially prepared science kits such a SCIS or ESS are used in addition to science textbooks.	1	2	3	4	5
29. Students use equipment and other science materials as a regular part of their science program.	1	2	3	4	5
30. Students conduct their own experiments.	1	2	3	4	5

APPENDIX B

STUDENT QUESTIONNAIRE

Name:_____ Your teacher:_____

A. These questions have no right or wrong answers. Please check the one response which best tells how you study in science.

MULTIPLE CHOICE

1. How often do you work in groups in science?
   _____often
   _____seldom

2. How often do you work by yourself in science?
   _____often
   _____sometimes
   _____seldom

3. How often do you have individual conferences with your teacher?
   _____often
   _____sometimes
   _____seldom

4. How often are the assignments the same for everyone?
   _____often
   _____seldom

5. Do you often help plan what activities you will do?
   _____no
   _____yes

6. Do you often help decide when your assignments will be due?
   _____no
   _____yes

7. How often do all students take the same test in a group at the same time?
   _____often
   _____sometimes
   _____seldom

APPENDIX C

Coding Scheme for Parent Education Level

0 = Unknown (not reported by school)

1 = No formal schooling (specifically reported)

2 = Some grade school (Grade 5 or less)

3 = Finished grade school (6th, 7th or 8th grade)

4 = Some high school

5 = Finished high school

6 = Some college (Nursing school included)

7 = Finished four-year college

8 = Some graduate, professional school

9 = Graduate or professional degree